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Challenges confronting construction information management

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This paper aims to present the results of an investigation of the prevailing challenges in construction information management. The study implemented a quantitative survey methodology, using a questionnaire to gather data from architects, civil engineers, quantity surveyors, mechanical and electrical engineers, construction managers, and project managers. Data analysis was conducted using the SPSS software package: applicable measures of dispersal were computed and inferential statistical tests performed. The study revealed that information management is a significant aspect of construction procedures and that a well-structured information system must be in place to achieve success in the construction domain. Additionally, the researchers discovered that construction information management could be affected by both internal and external factors within an organization. Further findings revealed that the major challenges in construction information management are long-term reliance on legacy systems, a lack of technological equipment, leadership development, poor financial investment in infrastructure for data management, and the implementation of appropriate policies by management. The primary contribution of this study lies in its appraisal of the difficulties facing construction information management and its identification of the relevant challenges, which can help in the proposal of solutions to improve methods of managing construction information, in turn producing improved performance and more efficient delivery of services on the part of professionals within the construction industry.

KEYWORDS

challenges, construction, information management, 4IR exploratory factor analysis, data

Introduction

Data management can be expected to constitute a fundamental practice of any organization in the 21st century. Data management permits establishments to achieve greater efficiency by sharing data throughout all the elements or departments of the organization (Penn and Pennix, 2017). This sharing prompts every employee of the establishment to function collectively, by creating an environment in which each employee has access to pertinent information regarding the activities of other employees (Dibbern et al., 2004). Data management is a practice that usually brings with it inherent challenges across all sectors, including the construction industry (Sadeghi et al., 2015). Due to the particular interconnection of the construction industry with the rest of the economy and society, the justification for investing in information management goes beyond simply increasing efficiency (Feng et al., 2017). The sector creates the networks that link people, organizations, and markets, laying the groundwork for burgeoning local economies. Information management may significantly increase the effectiveness and efficiency with which a nation's built assets are planned, constructed, and managed (Mêda et al., 2021). These built assets are essential for the population's economic wellbeing as well as the economic growth and competitiveness of the average country. Recent research demonstrates that most construction organizations handle information centrally, enabling everyone involved in a particular project or program to allocate their time and resources as efficiently as possible to achieve the desired outcomes (Guillen et al., 2016; Crowther and Ajayi, 2021).

The term construction information management system refers to a piece of interactive software or a hardware management system used in the construction environment to communicate with all necessary parties (Norouzi et al., 2015). This type of system has also been established as a way to track project budgets and expenses, gather and record all necessary approvals, and serve as a central repository for contracts, purchase orders, and other documents throughout the project lifecycle (Kannry and Fridsma, 2016). Additionally, this method can serve to visualize a facility's physical and functional aspects, either digitally or traditionally. In regard to information about a facility that can be used as a solid foundation for choices throughout its life cycle, which is defined as lasting from initial conceptualization to demolition, construction information management systems represent shared knowledge resources (Najjar et al., 2017). For instance, using computer-aided design and management software to manage designs and assets reduces the possibility of inaccuracies in reporting, poor decision-making, and poor project performance. However, various issues obstruct engineering and administrative success in relation to information management in construction locations (Peansupp and Walker, 2006). These issues influence time management, financial planning, design, and specifications, and they regularly cause delays, defects, and disputes. Numerous building site strategies and techniques have remained unaltered over the long term, and similar errors occur repeatedly (Hussain and Al-Tudjman, 2021). The principal reasons for this relate to the fact that site administration is described as involving a very heavy workload, long working hours, and many clashing activities to manage, including the administration of subcontracted workers for hire and contact with customers (Griffith and Watson, 2004). For example, the issues distinguished within site administration practices can be classified into three principal categories: board and organizational issues, specialized and design-related issues, and site correspondence issues (Kaliba et al., 2009). Most construction establishments have arrangements that specify processes by which the site administrator should notify the executives and the organization of any issues encountered (Azis et al., 2012). These issues must be addressed to guarantee that project targets are accomplished.

Furthermore, a wide range of scenarios requiring a response could arise in the vicinity of the project, and the site coordinator should be prepared to manage any of these in a precise and productive manner (Mohamed and Anumba, 2006a). Therefore, understanding the diverse characteristics of the challenges confronting construction information management can offer a practical insight into delays in construction processes and the causes of project abandonment, especially in underdeveloped and developing countries. The following sections of this paper present a comprehensive survey of the literature vis-à-vis the challenges of construction information management, the methodology implemented in this research, the findings, a discussion of the results, and the conclusions derived from them. This study is crucial because, in contrast to other industries, the construction industry faces numerous obstacles that must be overcome to integrate information management effectively. Through awareness of these challenges, construction establishments will be able to reduce the negative consequences of poor information management.

Information management in the construction industry

Construction projects commonly have stakeholders falling into five categories: clients, general project workers, subcontractors, advisors, suppliers, and relevant organizations (Zhiliang and Liang, 2004). In a perfect world, multiple forms of hierarchical structure for the management of these relationships could be conceived of, connecting these stakeholders in various ways (Vallas and Christin, 2108). For instance, there is an information cycle in which, in accordance with the hierarchy, the overall project coordinator signs a comprehensive agreement with the client, and subsequently, the project coordinator signs contracts with multiple subcontractors. In another cycle, the

TABLE 1 List of challenges in construction information management.

Code	Challenge	Authors
CM1	Unauthorized access to sensitive information	Laudon. (2006)
CM2	Undefined path to relevant information	Tombesi et al. (2009); Tombesi. (2004)
CM3	Inconsistent pattern of information system	Bottero et al. (2012)
CM4	Unsuitable implementation of information system	Hogan, (2009)
CM5	Continued use of old information technologies	Roe. (2019)
CM6	Analysis and mining of data	Ware et al. (2019); Babaei and Beikzad, (2013)
CM7	Data size	Zhang et al. (2013)
CM8	Low data bandwidth	Faris, (2019)
CM9	Inconsistent data format	Ceruti, (2004)
CM10	Undefined transmission standard	Jones, (2019); Truelook, (2019)
CM11	Poor financial investment in infrastructure for data management	Babaei and Beikzad, (2013)
CM12	Variation in funds spent on data management	Jones, (2019); Smith, (2014)
CM13	Poorly organized methods of cost budgeting and forecasting	Oke et al. (2013), Tanga et al. (2021)
CM14	Misappropriation of funds meant for data management	PointFuse, (2021); Ceruti, (2004)
CM15	Lack of technological equipment	Ofori, (2000); Mohamed and Anumba, (2006a)
CM16	Poor quality of equipment	Griffith and Watson, (2004)
CM17	Disorganized mode of operation	D4H Technologies, (2021); Chen, (2019)
CM18	Inexperienced operational personnel	Mohamed and Anumba, (2006b)
CM19	Disorganized documentation	Smith, (2014); Tanga et al. (2022)
CM20	Management implementing inappropriate policies	Hoezem et al., (2006); Page, (2021)
CM21	Lack of skilled professionals	Whittaker, (2011); Teevan et al. (2004)
CM22	Succession planning	Jones, (2019)
CM23	Change in management	Alon and Nachmias, (2020); Dumais et al. (2003)
CM24	Leadership development	Dinneen and Frissen, (2020)
CM25	Long-term reliance on legacy system	Bergman et al. (2009)

hierarchical structure may be such that the client signs an agreement with the main contractor for hire covering a significant portion of the project and subsequently assigns the remaining pieces of the task to sub-project executors. Under this type of arrangement, subcontractors hired for such a cycle are required to adhere to the overall project coordinator's plans throughout the project's duration (Bolumole, 2017).

Data management exercises in construction projects are completed under administrative instruction and can be organized in various ways (Isikdag, 2012). The administrative aspects can be categorized into administration exercises on time management, cost, quality, security, agreements, material and machines, H.R., and so forth (Lee and Yu, 2012). The relevant elements of such exercises may also be divided into two categories relating to different aspects of data management. One of these categories consists of record-keeping exercises, which require the participant to enter some form of data, for example in making arrangements for a cost assessment (Leigh et al., 2021). This type of assignment frequently consists of a series of successive data handling steps, such as submission, review, and endorsement. The other category consists of tasks that involve no records, which require no data to be contributed: for example, checking the result obtained by running the data administration framework.

Theoretical background

Since knowledge is the foundation of competition and the vast majority of the construction industry is becoming

TABLE 2 Challenges in construction information management.

Challenge	Mean	Std. Deviation	Rank	Shapiro–Wilk	
				Statistic	Sig
Long-term reliance on legacy system	4.87	0.337	1	0.695	0.000
Lack of technological equipment	4.83	0.425	2	0.726	0.000
Leadership development	4.83	0.409	2	0.748	0.000
Poor financial investment in infrastructure for data management	4.82	0.487	4	0.691	0.000
Management implementing inappropriate policies	4.82	0.445	4	0.733	0.000
Undefined transmission standard	4.81	0.472	6	0.910	0.000
Disorganized documentation	4.81	0.444	6	0.764	0.000
Analysis and mining of data	4.78	0.446	8	0.818	0.000
Misappropriation of funds meant for data management	4.77	0.454	9	0.833	0.000
Inexperienced operational personnel	4.76	0.486	10	0.820	0.000
Continued use of old information technologies	4.75	0.600	11	0.875	0.000
Unsuitable implementation of information system	4.75	0.493	11	0.834	0.000
Inconsistent data format	4.74	0.469	13	0.859	0.000
Change in management	4.73	0.447	14	0.856	0.000
Inconsistent pattern of information system	4.7	0.487	15	0.893	0.000
Poor quality of equipment	4.66	0.539	16	0.911	0.000
Low data bandwidth	4.64	0.581	17	0.915	0.000
Succession planning	4.64	0.507	17	0.932	0.000
Poorly organized methods of cost budgeting and forecasting	4.63	0.536	19	0.928	0.000
Lack of skilled professionals	4.62	0.561	20	0.914	0.000
Unauthorized access to sensitive information	4.59	0.633	21	0.902	0.000
Disorganized mode of operation	4.57	0.547	22	0.955	0.000
Data size	4.55	0.573	23	0.879	0.000
Variation in funds spent on data management	4.51	0.574	24	0.890	0.000
Undefined path to relevant information	4.45	0.583	25	0.757	0.000

increasingly information-intensive, information sharing among employees is seen as a key competitive advantage for a company (Adekunle et al., 2022a). In particular, it has become increasingly connected to organizational agility (Tallon et al., 2019), learning (Button et al., 2014), and innovation as this trend toward information-intensiveness throughout the majority of the construction industry has developed (Akcigit and Liu, 2016). As a result of the growth of information technology, construction businesses are developing their information systems (I.S.s), such as enterprise social media and content management systems, to facilitate their employees' behavior surrounding information management. For this reason, numerous studies have been conducted to examine the origins of information sharing from the perspective of information systems and their development in response to real-world needs and challenges in I.S. management.

Examining this issue from the perspectives of social capital theory (Lin et al., 2017), attitude theory (Argyriou and Melewar, 2011; Hsu, 2022), and organization theory (Garrido-Pelaz et al., 2016; Karlsson et al., 2017), researchers have identified a wide range of relevant variables, including social capital, the positive effects of employment, and organizational identity. Their relative power to explain the use of information sharing systems indicates that human motivation is rooted in compensation, reputation, reciprocity, self-worth, and satisfaction in helping others. Based on these results, various researchers hope to highlight further the important role of motivation in reevaluating employee behavior

TABLE 3 Cluster groupings for Challenges in Construction Information Management.

Cluster grouping	Eigenvalue	% of variance	Pattern matrix factor						
			1	2	3	4	5	6	7
FACTOR 1—Administrative Factor	7.314	29.257							
Analysis and mining of data			0.708						
Unauthorized access to sensitive information			0.696						
Continued use of old information technologies			0.692						
Poor financial investment in infrastructure for data management			0.688						
Lack of technological equipment			0.504						
FACTOR 2—Methodological Factor	1.923	7.693							
Poorly organized methods of cost budgeting and forecasting				0.843					
Undefined path to relevant information				0.615					
Inexperienced operational personnel				0.395					
FACTOR 3—Quality Factor	1.604	6.416							
Variation in funds spent on data management					0.727				
Poor quality of equipment					0.650				
Data size					0.639				
Leadership development					0.549				
Long-term reliance on legacy system					0.479				
FACTOR 4—Data Factor	1.316	5.265							
Inconsistent pattern of information system						0.816			
Low data bandwidth						0.577			
Disorganized documentation						0.467			
FACTOR 5—Management Factor	1.229	4.915							
Change in management							−0.847		
Management implementing inappropriate policies							−0.292		
Undefined transmission standard							−0.159		
Misappropriation of funds meant for data management							−0.149		
FACTOR 6—Operational Factor	1.139	4.555							
Disorganized mode of operation								0.721	
Succession planning								0.617	
Lack of skilled professionals								0.133	
FACTOR 7—Systematic Factor	1.022	4.090							
Inconsistent data format									−0.788
Unsuitable implementation of information system									−0.494
Total Variance Explained		62.191							

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with respect to information use from a personal information management perspective. Positive actions, which are all more likely to be taken by motivated employees, include information transparency (the disclosure of information about one's professional experience to others), information proactiveness, and information sharing (distribution of information in a collaborative manner) (Sun et al., 2018).

Since having a favourable attitude toward one's job may significantly improve one's inner motivation to share knowledge, job satisfaction (one of the positive emotions experienced by people at work) has recently been utilized to predict the use of information sharing systems, thereby forming a conceptual framework for the study of information systems (Mathieu et al., 2015; Brawley and Pury, 2016; Yılmaz et al., 2022). For instance, Morris and Venkatesh (2010) contend that, in contrast with positive effect, job satisfaction has traditionally been investigated as a more stable construct and that this characteristic accounts for its crucial impact on information sharing among workers. There is variation in the motivations and behaviors surrounding information sharing, which represents a challenge for information management in the construction industry because information sharing is a synergetic process that requires effort and costs time and energy (Mirzaee and Ghaffari, 2018). Although the importance of job satisfaction cannot be overstated, information sharing has recently drawn wider theoretical attention, since it underlies persistence of intention and higher motivation in situations pertaining to information systems. The ability of the current literature to contribute to construction information management may be constrained, nonetheless, by the failure of earlier work to recognize and explain the factors that have a detrimental influence on the management of construction information in a typical developing nation.

Since information sharing entails the flow of resources, which may be a requirement for most organizational operations, it is theoretically and practically significant (Zhou et al., 2020). Most empirical investigations have focused on identifying factors that overwhelm information sharing systems (Deng et al., 2017; Veltri and Atanasova, 2017; Bashir et al., 2021). Conveniently, these antecedents can be categorized into three groups: those relating to the presentation of information; the corporate culture; and the desire to share. First, regarding the type of information, sharing of tangible facts, for instance, may be dependent on people's pragmatic attitudes and organizational norms relating to ownership, whereas sharing of knowledge may depend on people's desire for self-expression (Tzafrir et al., 2015). Second, concerning the culture of the corporate work environment, this category of factors also contributes significantly in prediction of the use of information sharing systems, according to research examining such dimensions as organizational openness (Macnamara and Zerfass, 2012), member trust (Ford et al., 2017), and justice (Elamin and Alomaim, 2011). Third, conventional empirical research has shown that factors including job engagement (Teimouri et al., 2016), job attitudes (The and Sun, 2012), and positive effect toward work (Hajli and Lin, 2016) can be thought of as the most powerful motivators of information sharing. In particular, job satisfaction, a condition experienced by employees, may serve as a more reliable predictor of information sharing than positive affect toward work, which researchers frequently employ as a predictor of the use of information sharing systems.

Information systems can provide employees with a work environment where there are more opportunities for the exchange of information within and outside their organizations by highlighting, to some extent, the intrinsic limitations of data and information management. As a result, personal motivation to share has received more attention from researchers in the context of I.S. than the challenges encountered in sharing information (Kwon and Adler, 2014). There is broad consensus that an individual's desire to exert attentional effort is the primary factor underlying motivation under the circumstances typical for motivation studies. For instance, Hwang et al. (2015) described motivation as consisting of three sub-dimensions, namely direction, intensity, and persistence of attentional effort.

Using various motivational strategies, Bolisani and Scarso (2014) created a knowledge management framework with information sharing at its core. This framework includes strategies that encourage people to engage in tasks freely or in response to internal and external demands, as well as psychological components that promote people's relatedness, competence, and autonomy. In the context of I.S., motivation has also been operationalized in various ways. Adopting the perspectives of social exchange theory and attitude theory, several studies in the field of information systems have attempted to investigate how individual motivation affects information management (Jinyang, 2015; Zhang et al., 2018). These studies have highlighted the motivations underlying successful information management by examining variables that can be broadly divided into two categories: extrinsic motivation, in the form of social capital, reputation, and image; and intrinsic motivation, in the form of enjoyment of helping others, enjoyment of learning, and sense of self-worth.

Four types of motivation—for information transparency, information proactiveness, information sharing, and information formality—are included in a recent model that explains the function of motivation in personal information management in an I.S. environment (Hwang et al., 2018). All four reasons for engaging with information management systems focus on an individual's desire to put effort into making use of information. When people are highly motivated to seek out knowledge in order to improve the goods or services they provide as part of their jobs, this is known as proactiveness (Naseer et al., 2021). Following this, they may share information in a cooperative way (Ge et al., 2020), be transparent about unpleasant work experiences for the benefit of other employees

(Christofides et al., 2012), and adopt formal information communication patterns (formality) (Townsend et al., 2013). The challenges encountered in managing the vast amounts of information involved in construction represent a limitation on this set of motivations. Consequently, this study aimed to pinpoint the difficulties inherent in the process of organizing information in the construction domain.

Identification of challenges in construction information management

The concept of this design, involving the assessment of challenges in construction, is the assessment of a wide range of projects, highlighting construction-related deficiencies of various types in the process; these can primarily be attributed to inadequate harmonization between the various dimensions of the design process (Laudon, 2015). This type of assessment incorporates interface coordination, artistry control, organizational maintenance, the interactions between parts, hazard-related conduct, conflicts between practical projects and the specifications of the corresponding procurement plan or the project's expected performance, recognised vacuums, and insight gaps in construction (Tombesi et al., 2009). Supervision of a given project, from a design perspective, also implies a guarantee of consistency across the various logistical activity streams executed throughout the project's supply chain, which will eventually have significance for the value of the building constructed (D4H Technologies). This design perspective can be thought of as a procedure characterized by interdependence and ambiguity, in which the influence of certain vital factors can extend beyond the immediate predetermined environment of the project and thus beyond the network of arrangements activated within it (Hogan, 2009). The division of responsibilities under a given plan has particular social undertones that precede and modulate project-specific arrangements; however, this can impact the nature of the work performed against such a backdrop, by generating opportunities for connection that either help with the successful coordination of individual efforts or promote awareness of common obstructions or obstacles (Page, 2021).

Patterns in information principles demonstrate expectations for how typical information issues and segment data will be assembled (Hogan, 2009). The ideologies espoused during the set-up of information management systems universally include the use of well-defined information, standardization of questions, and recognition of response options that provide access to a reliable range of practices (Ware et al., 2019). There are, at present, many public and widespread information procedures that are employed to assemble and communicate project information. These ideologies are only extensively applied in certain scenarios and might contradict one another, which can influence the likelihood of relevant information being collected (Babaei and Beikzad, 2013). Different administrations might also use different guidelines, relying upon what they generally find to be vital for the execution of projects. Accordingly, the extent and granularity of data collection may vary across administrations, creating a need for multifaceted investigation of information use across administrations or *via* publicly available informational indices (Zhang et al., 2013). The absence, up to this point, of an organized effort among clients (including government clients), workers for hire, consultants, and different organizations to normalize information collection implies a wide variety of approaches to the gathering and recording of data (Faris, 2019).

The administration and control of expenses is crucial to most projects; however, heavy delays to project delivery and associated costs are commonplace around the world (Laudon, 2015). This might generally be attributed to inadequate methods of identifying, managing, and guiding clients' expectations, the scope of the project, and the cost of contracts (Babaei and Beikzad, 2013). Several incidents involving major budget overspending on significant projects around the world, on the order of millions or billions of dollars, have provoked concern and attention across all cultures (Oke et al., 2013). The worldwide economic crisis in 2008 further aggravated this challenge and regularly affected construction financing around the world, as financiers tightened controls on lending and abstained from providing loans for projects lacking adequate risk management (Smith, 2014). States, major private sector engineering companies, agents, and worldwide stakeholders like the United Nations, the World Bank, and the World Trade Organization have increasingly perceived the need for effective additional expense controls for construction projects (Jones, 2019). This range of views from these noteworthy establishments provides a helpful global overview for project leadership, amplifying the importance of project expenses and bringing these matters to the attention of the public. This creates awareness of the significance and benefits of employing cost-plan experts instead of engaging other construction professionals to carry out this function as part of their general roles (Dahmas et al., 2019).

To organize activities in a manner that improves construction project success, it is vital to understand the essential elements of the work to be done, the after-the-fact impact of the task, the consequences for performance that innovation can have, and the impact of relentless commercialization around the world (Ofori, 2000). The establishment of effective procedures and tools is imperative in order to provide value in a competitive manner in the daily quest for client or customer satisfaction (Whittaker, 2011). What factors influence purchasing decisions relating to these tools? For most establishments and construction conglomerates, the basic factors are value, excellence, task performance, characteristics, product range, and availability (Griffith and Watson, 2004). These various factors are also greatly influenced by other operational actions that may be undertaken. For example, production cost is devalued when utility rises and product value falls. Additionally, quality and range might expand as better creative techniques are developed (D4H Technologies).

Throughout the course of an ordinary day, construction employees may experience the need for data, whether in large or modest quantities, on multiple occasions (e.g., "When is my next meeting?"; "What's the situation with the proposed financial plan?"; "What's in the news today?"), prompting them to repeatedly seek out the required information (Whittaker, 2011). A large portion of research on data seeking, data-related conduct, and data recovery relates specifically to efforts to find data in open spaces like the web or a standard library (Teevan et al., 2004). There is even a substantial role played by individuals in attempts to track down new data, in ways never experienced up until recently, from a general repository like the web (Whittaker et al., 2011). For instance, attempts to find the right data might be coordinated by an *ad hoc* blueprint, a self-addressed email update, or a daily agenda. Furthermore, data within an employee's personal system can be utilized to help conduct a more specific, customized search of the web (Whittaker, 2011). Against this backdrop of extensive knowledge and understanding, the various challenges of construction information management were assessed in this study, as seen in Table 1.

Research methodology

This study was designed to evaluate the fundamental challenges facing construction information management. In doing so, it followed the conventional methodological approach adopted by Akinradewo et al. (2021). The study began with an acknowledgement of the full extent of the inquiry and a thorough review of the current literature on similar topics in line with the objectives of the study. Following this review, a survey was carried out, with a questionnaire as the research instrument. The data collected *via* this survey were analyzed, interpretations were made on the basis of this analysis, and conclusions were drawn. The choice of a questionnaire methodology to collect quantitative data was made on the basis that the study sought responses from professionals across the entire construction industry. Using a qualitative method, with data collected *via* an interview or complementary methods, would have been time-consuming and realistically almost impossible to accomplish. Thus, the questionnaire approach was considered appropriate for its simplicity in terms of procedure and capacity to capture data from a broader array of professionals within a very short timeframe (McGuirk and O'Neill, 2005).

Furthermore, use of a questionnaire can ensure quantifiability and objectivity in investigations (Bartram and Lambert, 2019). The questionnaire is among the most commonly used methods in social research, hence its implementation in this case. The questionnaire employed was closed-ended and consisted of two sections, with the first designed to collect data on the respondent's identity and the second to gather information on the challenges of construction information management. Respondents were asked to rate the extent of their agreement with each of 25 items using a five-point Likert scale, with five representing "strongly agree," four "agree," three "neutral," two "disagree," and one "strongly disagree." A related approach has been employed in studies on the development and advancement of green building technologies and sustainable construction practices (Chan et al., 2017; Aghimien et al., 2018). The questionnaire was circulated among architects, civil engineers, mechanical and electrical engineers, quantity surveyors, construction managers, construction project managers, and project managers due to their role in the preparation of construction documents and the supervision of construction projects. The questionnaire was distributed only to professionals practicing in South Africa. This choice was made following Rowley (Rowley, 2014); as it was not possible to assess all construction professionals due to the vast nature of the population, this approach allowed a portion of the targeted population to be evaluated. An online questionnaire was employed for ease in collecting a range of opinions.

Experts were identified using various online professional databases and were sampled in accordance with their willingness to participate in the survey. Additionally, a snowball method was employed to expand the scope of the survey. This became vital because of obstacles encountered in attempting to contact a portion of these experts, as it was not always possible to send direct messages to them. The snowball approach can be helpful when there is a need to expand the sample size (Handcock and Gile, 2011), as in this case. This methodology is similar to that employed by Baltar and Brunet (2012) and Akinradewo et al. (2021). Following the methods described, it is possible to determine the specific number of online questionnaires that should be in circulation in order to achieve a particular estimated response rate. Despite the challenges, a total of 154 responses were collected; this was regarded as sufficient for the study, following the assertion by Malterud et al. (2016) that the more data the sample covers, the greater the legitimacy of the information supplied.

The data were analyzed by first testing for normality using the Shapiro–Wilk test, and by testing the reliability of the measurement instrument by calculating Cronbach's alpha. Cronbach's alpha takes a range of values between 0 and 1; the higher the value, the more reliable the data that has been gathered (Heo et al., 2015). An alpha value of 0.880 was calculated for the 25 items surveyed, which shows that the instrument is dependable. The structural validity of the measurement scale employed was additionally tested using the Kaiser–Meyer–Olkin (KMO) test and Bartlett test. The outcome of the former was a KMO value of 0.741, while the Bartlett test gave an estimated chisquare of 1,501.19 at 300 degrees of freedom and a significant *p*-value of 0.000. This outcome suggests that the scale employed was a valid tool for what it was intended to evaluate, as the ideal values in these tests are a KMO value of 0.60 or more and a *p*-value of under 0.05 for the Bartlett test (Biasutti and Frate, 2017). In the subsequent phase of analysis, mean item score (MIS) was used to rank the challenges recognized by participants by level of importance. This was combined with the inferred standard deviation (S.D.) for each challenge. The challenges were ordered from highest MIS to lowest; however, where two factors had a similar MIS, the one with the lowest S.D. was ranked higher, as recommended by Zijlmans et al. (2019). Finally, exploratory factor analysis was conducted to reduce the large number of variables to a smaller set of summary variables and to explore the underlying theoretical structure of the phenomena. Factor loadings with negative values in the analysis indicated that the corresponding variables were to be interpreted in the opposite direction (Hair et al., 2012).

Findings and discussion

The analysis revealed that, in terms of gender, more responses were obtained from men, who accounted for 64.3% of respondents, while 35.7% were women. Regarding profession, 16.9% of respondents were architects, 13.6% were civil engineers, 15.6% were mechanical and electrical engineers, 22.7% were quantity surveyors, 3.9% were construction project managers, 11% were construction managers, and 16.2% were project managers. In addition, 49.4% of the respondents worked for a contracting firm, 29.9% worked as consultants. And 20.8% worked for the government. Furthermore, over 87% of the respondents reported having worked on more than six projects, while the remaining 13% had worked on six projects or fewer. On average, more than 80% had over 5 years of working experience, which is a considerably high proportion and makes the responses reliable and credible.

As illustrated in Table 2, the most significant challenge in construction information management was "Long-term reliance on legacy system," with a mean score (M) of 4.87 and standard deviation (S.D.) of 0.337. The other most significant challenges included "Lack of technological equipment" (M = 4.83; SD = 0.425), "Leadership development" (M = 4.83; SD = 409), "Poor financial investment in infrastructure for data management" (M = 4.82; SD = 0.487), and "Management implementing inappropriate policies" (M = 4.82; 0.445). The results of the Shapiro—Wilk test for normality are also presented in the table; the significance value for all 23 of the challenges assessed was well below the criterion of 0.05 required to indicate normality. This implies that the data were distributed non-parametrically. The results additionally revealed, as illustrated in the table, that the mean score for every factor assessed was higher than the scale's mid-point of 3.0, which suggests that the respondents agreed that the role of every one of the 25 variables was substantial.

Based on the pattern matrix presented in Table 3, the 25 variables identified from the literature fell into seven clusters; these clusters may be interpreted based on the inherent relationships observed among the variables in each cluster.

A total of five variables loaded onto cluster 1, as shown in Table 3. These variables were "Analysis and mining of data" (70.8%), "Unauthorized access to sensitive information" (69.6%), "Continued use of old information technologies" (69.2%), "Poor financial investment in infrastructure for data management" (68.8%) and "Lack of technological equipment" (50.4%). All these can be observed to relate to negligence on the part of the leadership of the organization. Therefore, this factor cluster can be termed the "Administrative Factor"; with a variance of 29.257%, it was a significant factor affecting effective and efficient information management in construction.

Three variables loaded onto cluster 2. These variables were "Poorly organized methods of cost budgeting and forecasting" (84.3%), "Undefined path to relevant information" (61.5%), and "Inexperienced operational personnel" (39.5%). The common themes in this cluster were unprofessionalism and lack of capacity among employees. The cluster is therefore labeled the "Methodological Factor," and has a total variance of 7.693%. This cluster was ranked behind cluster 1 as a factor affecting information management in construction.

Cluster 3 had five variables loading onto it. These variables were "Variation in funds spent on data management" (72.7%), 'Poor quality of equipment" (65.0%), "Data size" (63.9%), "Leadership development" (54.9%), and "Long-term reliance on legacy systems" (47.9%). These variables related primarily to the characteristics of a firm's management of its activities, and the cluster was therefore labeled the "Quality Factor." This cluster accounted for 6.416% of the total variance, and was thus ranked third among the factors affecting information management in construction.

The fourth cluster consisted of three variables, namely "Inconsistent pattern of information system" (81.6%), "Low data bandwidth" (57.7%), and "'Disorganized documentation" (46.7%). These two factors related to dysfunction of the human resources department, and the cluster can be labeled as the "Data Factor". This cluster had a total variance of 5.265%.

Cluster five had four variables loading onto it. These variables were "Change in management" (−84.7%), "Management implementing inappropriate policies" (−29.2%), "Undefined transmission standard" (−15.9%) and "Misappropriation of funds meant for data management" (−14.9%). These variables relatde largely to the characteristics of the data system, and this cluster was therefore labeled the "Management Factor." This cluster accounted for a total of 4.915% of the variance. Factor loadings onto this cluster were negative, which implies that the variables are to be interpreted in the opposite direction.

The sixth cluster consisted of three variables, namely "Disorganized mode of operation" (72.1%), "Succession planning" (61.7%), and "Lack of skilled professionals" (13.3%). All these factors related to the firm's mode of operation, so the cluster can be given the label "Operational Factor." This cluster had a total variance of 4.555%.

The last cluster consisted of two variables, namely "Inconsistent data format" (−78.8%) and "Unsuitable implementation of information system" (−49.4%). Both these factors related to the firm's mode of operation, and the cluster can be given the label "Systematic Factor." This cluster had a total variance of 4.090%, making it the lowest-ranked cluster of factors affecting information management in construction. Factor loadings onto this cluster were also negative, which implies that the variables are to be interpreted in the opposite direction.

Table 3 shows the cluster groupings of the variables. The variables were grouped into seven factors. The first of these was the "Administrative Factor"; this was the most critical cluster of challenges, showing that failure to perform suitably or negligence of duty on the part of the administrative leadership is disruptive, and such failures should be regarded as misconduct if they purposely, knowingly, or consciously fail to perform their duties, execute them in a grossly neglectful manner, or constantly perform neglectfully after prior notification or reprimand and in flagrant violation of the firm's preferences (D4H Technologies).

Serious quality problems with administrative data might include missing data, inaccurate values, improper formatting, internal discrepancies, and outlying figures. To make sure any analysis is accurate and reliable, several types of problems with data quality must be rectified. Organizations should thoroughly analyze and clean their data before analyzing it to address this issue. Additionally, administrative data is frequently spread out across several databases or tables. No single dataset, or set of datasets in a single format, may contain all the data required for analysis or review. The company must combine administrative data from many sources to overcome this difficulty.

The second factor, which was the "Methodological Factor," was ranked second among the most critical clusters of challenges. This factor also showed that inexperienced workers need solidness; in most cases, they enter their profession without fixed plans and are prepared to move to organizations that offer excellent opportunities. This view is supported by Babaei and Beikzad (2013), who suggested that such employees additionally fall short in terms of their skills and understanding of work-related information, and need to be more thoroughly acquainted with the tools or programs required to carry out their work. Direct database access may be the best option when the construction-related data to be transferred consist of several linked elements or the precise components are unknown in advance, i.e., the required data elements fluctuate on an as-needed basis. The transfer technique could necessitate several database calls and code runs to reassemble the relationships between the different components of the data. For performance reasons, transfer of very large datasets frequently necessitates using a file transfer service or direct database connection. Selection of the best approach might be challenging, even if strategies are available to improve performance in transmission of very large datasets or large numbers of lengthy messages.

The findings further showed that quality management can be a simple issue if the appropriate project management tool is employed, as stated by Bolton et al. (2015). If complications do arise, this implies that the necessary combination of resources is not available. The presence of arrangements to carry out administrative exercises has not been found to be dependent on a particular set of events or logical effects, as hypothesized (Becerik-Gerber and Kent, 2010). The connection between cause and logical outcomes is inconsistent, and a variety of mediating links exist. Thanks to technology, construction companies can dramatically enhance and develop their systems, processes, and skill sets. All of this indicates that better information quality is urgently needed to support the smooth operation of the company as a whole. While intermediate management staff and employees frequently welcome innovations and advances, staff at higher levels of management often reject technology. Members of upper management frequently believe that new technologies are unnecessary in some cases and consume too much time and too many resources. This resistance has hindered quality improvements. The use of heritage systems and a mentality that opposes change may permeate upper management and entire organizations. Most information systems represent a significant time and money commitment for the company and are seldom voluntarily updated. This is understandable; however, businesses must be quick to adopt new technology, since the volume of information they must handle is growing dramatically and is related to globalization. Neglecting to do so is a mistake that might be deadly to a company.

The "Data Factor" is also a challenge confronting construction information management, as identified by this study. Globally, daily operations and strategic business choices in the construction industry are becoming increasingly dependent on data (Faris, 2019; Ceruti, 2004). It has become challenging to manage data throughout a given corporation, which may be scattered over many geolocations and may employ dozens of business line apps due to the vast amount of data being generated. Companies expend a large amount of effort and money to establish dependable decision support systems enabling them to make informed business decisions. Data quality and accessibility directly affect how a business makes decisions and how its operations are executed.

The department of human resources is likewise fundamental to any construction organization. This office is responsible for directing the traditional elements of an establishment. In this capacity, it has a major effect on all levels of the organization. Without viable human resource management, the establishment's practices could encounter genuine legal, financial, and efficiency issues (Mohamed and Anumba, 2006a). The most critical factor for success in this domain is the shift to digital operations (Dumais et al., 2003; Alon and Nachmias, 2020). Aside from requiring an appropriate information management plan, organizational strategy, and change management vision, success in making this shift also requires suitable tools to assist the organization in digitizing its data and achieving high levels of return on investment (ROI). Due to the very large volume of information and paperwork involved, reliance solely on paper records will seriously hinder operational progress. However, digitizing documents is a complicated procedure. It requires a lot of initial work, particularly for an employee who has been at their company for some time and has many paper records saved. Sensitive data should be protected, including client information, employee information, and financial reports. Only authorized people should have access to these in order to avoid data breaches and maintain a positive reputation.

Furthermore, the results showed that a framework for information management must cover several activities, namely the acquisition, storage, and secure use of data in a beneficial and financially responsible manner. The purpose of data management systems is to assist organizations and their staff in updating their use of data within the constraints of specified techniques and guidelines so that they can identify and take steps for the benefit of the establishment (Faris, 2019). The vigorous practice of information administration is becoming a higher priority than at any moment in recent memory, as establishments necessarily rely on resources with increasingly subtle interdependencies to maintain their reputation. Information intricacy of an establishment might depend upon how an establishment is portrayed as regards to information management systems. An organization's regulatory model will generally add unproductive complications to some cycles of information management through the inclusion of many steps and individuals, which is a trait of nineteenth-century innovations (Jones, 2019). The current findings support the view proposed by Alon and Nachmias (2020), who claim that a legacy system runs more slowly, takes more time to execute assignments, and requires considerably more tedious support, patches, updates, and helpdesk calls than its more up-to-date counterparts.

The results of this study also showed that construction firms encountering challenges with data management still need to implement suitable information management systems to handle the large and dynamic amounts of information involved in construction management. This systematic factor was the lowest ranked among the clusters of critical challenges. Adekunle et al. (2022b) research, which claims that construction projects are dynamic and that project coordinators must considerably alter information systems in order to accommodate the most recent supplier information, regulations, or temporary changes, supports this view. There is frequently a delay between the time at which a particular piece of data becomes available and the time at which it is communicated to the various stakeholders and team members. To guarantee that project managers, business executives, and on-site workers always have access to the most recent information, construction businesses must ensure that all data is maintained in a single data bank. Use of a single data source also reduces the possibility that information may be misread or interpreted without the context provided by essential supplementary information. The collection of many types of data is necessary for construction projects. Project managers may ensure they extract all the information they can from their data pool using effective data management practices. Through effective integration, multiple systems can cooperate suitably and systematically. Under this approach, enterprises in the construction industry will be able to maximize their use of existing digital tools, combine data sources, and improve information access throughout the organization.

Implications of the study

Management of construction-related information is a major task for construction stakeholders and the industry as a whole. Not only are more databases, knowledge bases, websites, information systems, and information representations now available, but users are also demanding quicker, more prominent, and more effective information systems, which is why this shift is occurring. Difficulties with scalability become increasingly significant when datasets, knowledge bases, and information systems expand in size and number. To aid with overcoming obstacles in construction information management, information should be stored in a wide variety of data formats, knowledge representations, and models, because construction companies generate data targeting various objectives. The need to handle complexity and embrace scalability is highlighted by the growing need for the ability to obtain more precise information, and to do so more quickly, in many vital applications. The findings of this study indicate that the administrative component is the most significant hurdle for information management in construction; thus, implementation of effective and efficient construction information management system will be performed in the administrative leadership capacity of a typical construction establishment.

Construction stakeholders need to understand how to ensure successful information management in light of what might happen in its absence; investigation of the issues surrounding construction information management in a typical developing nation indicates that this is essential. This study showed that the absence of a defined data administration strategy could cause syntactic and semantic heterogeneity, increasing downstream challenges in data integration to a degree that is often insurmountable. When such problems still need to be solved, interoperability is a necessary but insufficient precondition for integration. Data aggregation can expose more sensitive information *via* inference, presenting an unknowable and frequently unanticipated security hazard. Therefore, incidents of denial of service, fragmented records, and a lack of referential integrity, for example, are data access failures that can result in duplication of effort, cost inefficiencies, missed commercial opportunities, medical catastrophes, and military disasters; these outcomes should be avoided. Through consideration of the critical challenges described in this article, construction establishments will become fully aware of the factors that pose threats to effective and efficient construction information management.

Conclusion

As a component of construction management, construction information management has its own set of problems and remedies. The primary issues affecting construction information management as a process and the field of construction information management as a whole were examined as part of this study *via* a review of the pertinent literature. This review indicated that construction information management can be affected by factors both internal and external to a given organization. Among these factors, those identified included: an undefined path to relevant information; variation in the funds spent on data management; data size; unauthorized access to sensitive information; disorganized modes of operation; a lack of skilled professionals; inconsistent data format; analyis and mining of data; the continued use of old technologies; and so on. This study concludes that, based on the primary data collected and analyzed, the critical challenge in construction information management is a cluster of factors pertaining to negligence on the part of administrative officers, such as disorganized documentation, a lack of technological equipment, inconsistent patterns in the information system, misappropriation of funds meant for data management, low data bandwidth, undefined transmission standards, and succession planning.

This study has revealed that construction information management suffers from a lack of information systems, as in many scenarios information on projects is not available or is not suitably stored or managed for stress-free access, retrieval, and use in current or subsequent projects. Consequently, there is a need for appropriate documentation of previously executed projects to ensure the proper delivery of projects and the existence of essential points of reference when handling new tasks. Finally, governments are expected to be keenly involved in upholding fourth industrial revolution (4IR) tools through the formation of policies and by facilitating means of imposing these for use in construction information management. Additionally, governments can sustain the construction industry through the appraisal and introduction of bills and policies and in the outline of building codes, incentives, and supplementary fiscal mechanisms necessary for 4IR adoption.

The results of the study will help readers, researchers, and especially construction stakeholders to understand the value of conducting thorough analyses by removing informational impediments to strategic decision-making in regard to target setting, resource allocation, demonstration of social impact, and improvements to organizational performance. The factor analysis conducted in this study has dramatically decreased the number of relevant variables, enabling construction stakeholders to commit fewer resources to address construction information management difficulties. Therefore, this study suggests that construction organizations should go beyond the policy setting and routinely communicate with stakeholders, engage staff in data archiving or disposal exercises, and reward behaviors promoting information security in order to alleviate the challenges surrounding information management in construction. Furthermore, as this study was limited to only two regions of South Africa, a follow-up study should be conducted in a comparable developing nation to corroborate the findings. Similar research should also be undertaken in other sectors, such as the manufacturing sector, to compare and contrast the results.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Author contributions

Conceptualization: PA, OA, and CA; methodology: PA and OA; software: PA and CA; validation: OA, CA, and WT; formal analysis: PA; investigation: PA and OA; resources: CA and OA; data curation: PA; writing—original draft preparation: PA; writing—review and editing: OA and CA; supervision: OA and CA. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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